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Solid Earth
Discussions

Interactive comment on "Using spectral analysis to detect singular events such as jerks in the geomagnetic field time series" *by* B. Duka et al.

B. Duka et al.

bejo.duka@unitir.edu.al

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Reply to Ref. 1

General comments:

This paper concerns the detection of impulse-like features in the temporal evolution of the Earth's magnetic field known as geomagnetic jerks, and an analysis of their spatial characteristics. The paper includes some methods which have not been tried before, and the most interesting new result is the possibility that these jerks are more dominant in the odd rather than the even spherical harmonic degrees. Another result is the detection of new jerks during the 20th century. These results may have some implications for understanding the geodynamo that generates the magnetic field. However I have a reservation concerning the use of the global models for detecting jerks, and fear this may jeopardise these results unless some additional work is done.

Reply:

The referee reservation concerning the use of global model is based on her specific comments. Please see our replies about these specific comments.

Specific comments:

1) Both global models used are based on splines which are continuous in their 2nd derivative. Applying discrete wavelet transforms (DWTs) which are designed to detect breakdown of the 2nd derivative to values derived form these models therefore seems unlikely to provide robust results. Would it be possible to provide supporting evidence that DWTs can be applied to such model values by comparing the results from DWTs on real observatory data with those on modelled data at the same locations? A similar comparison was done in Chambodut & Mandea (2005) where the CM4 model was used but is not directly applicable here because a different method of jerk detection was used, viz. piece-wise linear functions fitted to secular variation data. Wavelets only provided the a priori jerk dates in their work.

Reply:

In theory, this referee is right. This is because there is a linear relation between the field (and its temporal derivatives) and the Gauss coefficients (and their temporal derivatives). Therefore, in principle, imposing continuity on the second temporal derivatives through the B-splines, means theoretical continuity also in the derivatives of the field. Applying DWT on a continuous signal like (3) that has a breakdown of its derivative in one point (t =0), we get anomalous value of d1 coefficient strictly at this point. Applying DWT on continuous signal of SV generated by Gufm1 model, we get anomalous values of d1 coefficients extended in interval of points. Therefore, in our analyses we applied the 12 months averaging of d1 coefficients In practice the continuity of the signal does

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not significantly affect our results. To go more into some details, Gufm1 model divides the time period 1580-1990 in 163 knots (each 2.5 year interval) and when we calculate the field elements or their SV at a place and given time t, the program calculates the values of Gauss coefficients at this time as the combinations of the values of Gauss coefficients at 4 or 5 (depends from the order or B-splines) knots that are the nearest to time t. The coefficients of such compositions depend on the time distances of the node to the time t. Such coefficients are different for different time t, even when the same near knots are used. According to our tests, comparing the values of the field components and their SV at a place for two different times: t and t', it results that when the difference ïĄĎt = |t'-t|< 10-2 year, the values are almost the same, but when the difference ïĄĎt > 10-2 year, the values are quite different (the difference is larger than 0.1 nT/yr for SV and larger than 1 nT for the field components). As we are interested in series of monthly values (1 month = 0.0833 year), we are sure that we have a discrete time series. The obtained time series are smoothed in comparison to the observed time series, but we can detect significant change on their numerical time derivatives. A clear comparison is given by the results of the DWTs applied on the time series of SV of the observed Y-component and the time series of SV calculated from Gufm1 model at the same location (Niemegk Observatory), see figures 9 and 10 of the paper, respectively.

2) Due to the similarity of part of the section concerning the description of the discrete wavelet transform (section 3.2.1) to textbook material, it would be better placed in an appendix.

Reply:

In order to keep the self-consistency of this paper we will place the major part of 3.2.1 in an appendix.

3) Is the use of c(j,k) on page 627 eq(8) for the discrete wavelet transform the same as c(a,b) on page 626 eq(6), where I interpreted c to stand for "continuous" wavelet

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transform? I've seen T being used elsewhere for the DWT.

Reply:

The c letter stands for "coefficients" and not for "continuous". To avoid any confusion, we will consider the referee suggestion and use the T.

4) The paper would benefit from a description of how this application of wavelets to detect jerks differs from Alexandrescu's application.

Reply:

The geomagnetic jerk detection by applying the wavelets techniques has been a pioneering work done by Alexandrescu et al. (1995, 1996). Since, the wavelets analysis has dramatically improved, becoming nowadays a user-friendly technique. In this paper, we applied the discrete (not continuous as used by Alexandrescu et al., 1995, 1996) wavelet analyses and the choice of the mother wavelet is different from the previous one. We considered that such a statement is not useful to be developed in the main body of this contribution, as the Alexandrescu's papers have been referred in Introduction.

5) The interpretation of the results in Table 2 is a little subjective, particularly for degrees 1 and 2 and also given that 1986 is generally considered a poorly determined jerk. Given that this is the main new result of this paper, can it be made less subjective? For example could you score closeness of extremes to jerk dates, then sum the scores for each degree? The jerk dates could also be scored somehow, for example according to their global RMS d1 amplitudes, and incorporated into the interpretation. Some tightening up of the interpretation is required here, given that this is probably the most interesting result in the paper.

Reply:

We agree with the referee's comment that the results of Table 2 are apparently subjective and the jerk of 1986 is a poorly determined one. We will recompile the Table 2 in

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another way, more objective one, removing the 1986 jerk. We will calculate the time distance from extremes of the second time derivatives of Rn terms from one or two reasonable values of the time occurrence of the known jerks (beginning or middle of the year). The score of closeness and the sum of scores for each degree will be presented in the revised Table 2. We don't think we could score the jerk dates somehow, especially "according to their global RMS d1 amplitude" proposed by referee. The reason is that we think some jerks could happen locally, some other ones could happen globally. An alternative would be that we can weigh the extremes of the second time derivatives of Rn terms, as there are dipper or shallower minimums and higher or lower maxima. The height of maxima or the depth of minimum where there is the coincidence of a given jerk, could be some indication for judging if the jerk is more likely a local or a global one. We understand that this cannot give definitive answer about the global or local character of a certain jerk, but could be a possible measure of it.

6) In the discussions and conclusions, too much emphasis is put on the animation which is part of the supplementary material. Significant new points can be provided in this section but the main description of the animation should remain in section 3.2.4. One of the points touched upon in the discussions and conclusions is the apparent prevalence of sectoral (spherical harmonic order=degree) terms over zonal or tesseral terms. Is this real and can the authors comment on this?

Reply:

In the section 3.2.4, we have described the algorithm of calculations and the results of calculations, mainly the distribution of d1 field during the time period studied. We agree to add here the description of animation and to avoid any conclusion from here. Regarding the point of discussion and conclusion, mentioned by referee, we think that in the discussions and conclusions, we only noted a specific behavior of jerks (having as signatures strong fields of d1 coefficients): "they are distributed mostly in different longitude belts that present some kind of periodicity in the longitude". With a limited locations (212) of the averaged series of d1 coefficients values, we could not apply a spherical harmonic analysis of d1 coefficient field. The fact of having geomagnetic jerk distribution zones apparently sectorals, is an interesting aspect and would deserve more attention and more work. Indeed, this would need another entire paper to better exploit it, including some real analysis on model and/or simulations, and many more calculations. Thus, we are content to mention this feature in the present paper and to point out that: may be such a kind of distributions could be explained by a specific fluid flow at the top of the outer core.

Technical corrections:

Reply:

We agree with all technical corrections and we have taken all into account.

Interactive comment on Solid Earth Discuss., 3, 615, 2011.